

CLAIMS

What is claimed is:

1. A method for navigating a UAV, the method comprising:

5 receiving in a remote control device a user's selection of a GUI map pixel that represents a waypoint for UAV navigation, the pixel having a location on the GUI;

mapping the pixel's location on the GUI to Earth coordinates of the waypoint;

10 transmitting the coordinates of the waypoint to the UAV;

reading a starting position from a GPS receiver on the UAV; and

15 piloting the UAV, under control of a navigation computer on the UAV, from the starting position to the waypoint in accordance with a navigation algorithm.

2. The method of claim 1 further comprising:

receiving user selections of a multiplicity of GUI map pixels representing waypoints, each pixel having a location on the GUI

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mapping each pixel location to Earth coordinates of a waypoint;

assigning one or more UAV instructions to each waypoint;

10       transmitting the coordinates of the waypoints and the UAV instructions to the UAV;

storing the coordinates of the waypoints and the UAV instructions in computer memory on the UAV;

15       piloting the UAV to each waypoint in accordance with one or more navigation algorithms; and

20       operating the UAV at each waypoint in accordance with the UAV instructions for each waypoint.

3.       The method of claim 1 wherein mapping the pixel's location on the GUI to Earth coordinates of the waypoint further comprises:

mapping pixel boundaries of the GUI map to Earth coordinates;

5       identifying a range of latitude and a range of longitude represented by each pixel; and

10       locating a region on the surface of the Earth in dependence upon the boundaries, the ranges, and the location of the pixel on the GUI map.

4.       The method of claim 3 wherein locating a region on the surface of the Earth in dependence upon the boundaries, the ranges, and the location of the pixel on

the GUI map further comprises:

5 multiplying the range of longitude represented by each pixel by a column number of the selected pixel, yielding a first multiplicand;

multiplying the range of longitude represented by each pixel by 0.5, yielding a second multiplicand;

10 adding the first and second multiplicands to an origin longitude of the GUI map;

15 multiplying the range of latitude represented by each pixel by a row number of the selected pixel, yielding a third multiplicand;

multiplying the range of latitude represented by each pixel by 0.5, yielding a fourth multiplicand; and

20 adding the third and fourth multiplicands to an origin latitude of the GUI map.

5. The method of claim 1 wherein piloting in accordance with a navigation algorithm comprises periodically repeating the steps of:

reading from the GPS receiver a current position of the UAV;

5 calculating a heading from the current position to the waypoint;

turning the UAV to the heading; and

- 10 flying the UAV on the heading.
6. The method of claim 1 wherein piloting in accordance with a navigation algorithm comprises identifying a cross track between the starting point and the waypoint, and repeatedly carrying out the steps of:
- 5 reading from the GPS receiver a current position of the UAV;
- calculating a shortest distance between the current position and the cross track; and
- 10 if the shortest distance between the current position and the cross track is greater than a threshold distance, piloting the UAV toward the cross track, and, upon arriving at the cross track, piloting the UAV in a cross track direction toward the waypoint.
7. The method of claim 6 wherein calculating a shortest distance between the current position and the cross track comprises:
- calculating the distance from the current position to the waypoint;
- 5 calculating the angle between a direction from the current position to the waypoint and a cross track direction;
- calculating the tangent of the angle; and
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multiplying the tangent of the angle by the distance from the current position to the waypoint.

8. The method of claim 1 wherein piloting in accordance with a navigation algorithm comprises identifying a cross track having a cross track direction between the starting point and the waypoint, and repeatedly carrying out the steps of:

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reading from the GPS receiver a current position of the UAV;

calculating an angle between the direction from the current position to the waypoint and a cross track direction; and

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if the angle is greater than a threshold angle, piloting the UAV toward the cross track, and, upon arriving at the cross track, piloting the UAV in the cross track direction.

9. The method of claim 8 wherein the threshold angle is a variable whose value varies in dependence upon a distance between the UAV and the waypoint.

10. The method of claim 1 wherein piloting in accordance with a navigation algorithm comprises periodically repeating the steps of:

reading from the GPS receiver a current position of the UAV;

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calculating a direction to the waypoint from the current position;

calculating a heading in dependence upon wind speed, wind direction, air speed, and the direction to the waypoint;

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turning the UAV to the heading; and

flying the UAV on the heading.

11. The method of claim 1 further comprising identifying a cross track and calculating a cross track direction from the starting position to the waypoint, and piloting in accordance with a navigation algorithm comprises periodically repeating the steps of:

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reading from the GPS receiver a current position of the UAV;

calculating a shortest distance between the cross track and the current position; and

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if the shortest distance between the cross track and the current position is greater than a threshold distance, piloting the UAV to the cross track, and, upon arriving at the cross track:

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reading from the GPS receiver a new current position of the UAV;

calculating, in dependence upon wind speed, wind direction, air speed, and the cross track direction, a new heading;

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turning the UAV to the new heading; and

flying the UAV on the new heading.

12. A system for navigating a UAV, the system comprising:

5 means for receiving in a remote control device a user's selection of a GUI map pixel that represents a waypoint for UAV navigation, the pixel having a location on the GUI;

10 means for mapping the pixel's location on the GUI to Earth coordinates of the waypoint;

means for transmitting the coordinates of the waypoint to the UAV;

means for reading a starting position from a GPS receiver on the UAV; and

15 means for piloting the UAV, under control of a navigation computer on the UAV, from the starting position to the waypoint in accordance with a navigation algorithm.

13. The system of claim 12 further comprising:

5 means for receiving user selections of a multiplicity of GUI map pixels representing waypoints, each pixel having a location on the GUI

means for mapping each pixel location to Earth coordinates of a waypoint;

means for assigning one or more UAV instructions to each waypoint;



- 10 means for transmitting the coordinates of the waypoints and the UAV instructions to the UAV;
- means for storing the coordinates of the waypoints and the UAV instructions in computer memory on the UAV;
- 15 means for piloting the UAV to each waypoint in accordance with one or more navigation algorithms; and
- means for operating the UAV at each waypoint in accordance with the UAV instructions for each waypoint.
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14. The system of claim 12 wherein means for mapping the pixel's location on the GUI to Earth coordinates of the waypoint further comprises:
- means for mapping pixel boundaries of the GUI map to Earth coordinates;
- 5 means for identifying a range of latitude and a range of longitude represented by each pixel; and
- means for locating a region on the surface of the Earth in dependence upon the boundaries, the ranges, and the location of the pixel on the GUI map.
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15. The system of claim 14 wherein means for locating a region on the surface of the Earth in dependence upon the boundaries, the ranges, and the location of the pixel on the GUI map further comprises:

5 means for multiplying the range of longitude represented by each pixel by a column number of the selected pixel, yielding a first multiplicand;

means for multiplying the range of longitude represented by each pixel by 0.5, yielding a second multiplicand;

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means for adding the first and second multiplicands to an origin longitude of the GUI map;

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means for multiplying the range of latitude represented by each pixel by a row number of the selected pixel, yielding a third multiplicand;

means for multiplying the range of latitude represented by each pixel by 0.5, yielding a fourth multiplicand; and

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means for adding the third and fourth multiplicands to an origin latitude of the GUI map.

16. The system of claim 12 wherein means for piloting in accordance with a navigation algorithm comprises:

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means for reading from the GPS receiver a current position of the UAV;

means for calculating a heading from the current position to the waypoint;

means for turning the UAV to the heading; and

- 10 means for flying the UAV on the heading.
17. The system of claim 12 wherein means for piloting in accordance with a navigation algorithm comprises means for identifying a cross track between the starting point and the waypoint, and:
- 5 means for reading from the GPS receiver a current position of the UAV;
- means for calculating a shortest distance between the current position and the cross track; and
- 10 means for piloting the UAV toward the cross track,
- means for piloting the UAV in a cross track direction toward the waypoint.
18. The system of claim 17 wherein means for calculating a shortest distance between the current position and the cross track comprises:
- means for calculating the distance from the current position to the waypoint;
- 5 means for calculating the angle between a direction from the current position to the waypoint and a cross track direction;
- means for calculating the tangent of the angle; and
- 10 means for multiplying the tangent of the angle by the distance from the current position to the waypoint.

19. The system of claim 12 wherein means for piloting in accordance with a navigation algorithm comprises means for identifying a cross track having a cross track direction between the starting point and the waypoint, and:
- 5 means for reading from the GPS receiver a current position of the UAV;
- means for calculating an angle between the direction from the current position to the waypoint and a cross track direction; and
- 10 means for piloting the UAV toward the cross track, and
- means for piloting the UAV in the cross track direction.
20. The system of claim 19 wherein the threshold angle is a variable whose value varies in dependence upon a distance between the UAV and the waypoint.
21. The system of claim 12 wherein means for piloting in accordance with a navigation algorithm comprises:
- 5 means for reading from the GPS receiver a current position of the UAV;
- means for calculating a direction to the waypoint from the current position;
- means for calculating a heading in dependence upon wind speed, wind direction, air speed, and the direction to the waypoint;
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means for turning the UAV to the heading; and

means for flying the UAV on the heading.

22. The system of claim 12 further comprising means for identifying a cross track and calculating a cross track direction from the starting position to the waypoint, and means for piloting in accordance with a navigation algorithm comprises:

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means for reading from the GPS receiver a current position of the UAV;

means for calculating a shortest distance between the cross track and the current position; and

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means for piloting the UAV to the cross track; and

means for reading from the GPS receiver a new current position of the UAV;

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means for calculating, in dependence upon wind speed, wind direction, air speed, and the cross track direction, a new heading;

means for turning the UAV to the new heading; and

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means for flying the UAV on the new heading.

23. A computer program product for navigating a UAV, the computer program product comprising:

a recording medium;

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means, recorded on the recording medium, for receiving in a remote control device a user's selection of a GUI map pixel that represents a waypoint for UAV navigation, the pixel having a location on the GUI;

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means, recorded on the recording medium, for mapping the pixel's location on the GUI to Earth coordinates of the waypoint;

means, recorded on the recording medium, for transmitting the coordinates of the waypoint to the UAV;

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means, recorded on the recording medium, for reading a starting position from a GPS receiver on the UAV; and

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means, recorded on the recording medium, for piloting the UAV, under control of a navigation computer on the UAV, from the starting position to the waypoint in accordance with a navigation algorithm.

24. The computer program product of claim 23 further comprising:

means, recorded on the recording medium, for receiving user selections of a multiplicity of GUI map pixels representing waypoints, each pixel having a location on the GUI

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means, recorded on the recording medium, for mapping each pixel location to Earth coordinates of a waypoint;

10 means, recorded on the recording medium, for assigning one or more UAV instructions to each waypoint;

means, recorded on the recording medium, for transmitting the coordinates of the waypoints and the UAV instructions to the UAV;

15 means, recorded on the recording medium, for storing the coordinates of the waypoints and the UAV instructions in computer memory on the UAV;

20 means, recorded on the recording medium, for piloting the UAV to each waypoint in accordance with one or more navigation algorithms; and

means, recorded on the recording medium, for operating the UAV at each waypoint in accordance with the UAV instructions for each waypoint.

25. The computer program product of claim 23 wherein means, recorded on the recording medium, for mapping the pixel's location on the GUI to Earth coordinates of the waypoint further comprises:

5 means, recorded on the recording medium, for mapping pixel boundaries of the GUI map to Earth coordinates;

means, recorded on the recording medium, for identifying a range of latitude

and a range of longitude represented by each pixel; and

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means, recorded on the recording medium, for locating a region on the surface of the Earth in dependence upon the boundaries, the ranges, and the location of the pixel on the GUI map.

26. The computer program product of claim 24 wherein means, recorded on the recording medium, for locating a region on the surface of the Earth in dependence upon the boundaries, the ranges, and the location of the pixel on the GUI map further comprises:

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means, recorded on the recording medium, for multiplying the range of longitude represented by each pixel by a column number of the selected pixel, yielding a first multiplicand;

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means, recorded on the recording medium, for multiplying the range of longitude represented by each pixel by 0.5, yielding a second multiplicand;

means, recorded on the recording medium, for adding the first and second multiplicands to an origin longitude of the GUI map;

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means, recorded on the recording medium, for multiplying the range of latitude represented by each pixel by a row number of the selected pixel, yielding a third multiplicand;

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means, recorded on the recording medium, for multiplying the range of latitude represented by each pixel by 0.5, yielding a fourth multiplicand; and



means, recorded on the recording medium, for adding the third and fourth multiplicands to an origin latitude of the GUI map.

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27. The computer program product of claim 23 wherein means, recorded on the recording medium, for piloting in accordance with a navigation algorithm comprises:

5 means, recorded on the recording medium, for reading from the GPS receiver a current position of the UAV;

means, recorded on the recording medium, for calculating a heading from the current position to the waypoint;

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means, recorded on the recording medium, for turning the UAV to the heading; and

means, recorded on the recording medium, for flying the UAV on the heading.

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28. The computer program product of claim 23 wherein means, recorded on the recording medium, for piloting in accordance with a navigation algorithm comprises means, recorded on the recording medium, for identifying a cross track between the starting point and the waypoint, and:

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means, recorded on the recording medium, for reading from the GPS receiver a current position of the UAV;

10 means, recorded on the recording medium, for calculating a shortest distance between the current position and the cross track; and

means, recorded on the recording medium, for piloting the UAV toward the cross track,

15 means, recorded on the recording medium, for piloting the UAV in a cross track direction toward the waypoint.

29. The computer program product of claim 28 wherein means, recorded on the recording medium, for calculating a shortest distance between the current position and the cross track comprises:

5 means, recorded on the recording medium, for calculating the distance from the current position to the waypoint;

means, recorded on the recording medium, for calculating the angle between a direction from the current position to the waypoint and a cross track direction;  
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means, recorded on the recording medium, for calculating the tangent of the angle; and

means, recorded on the recording medium, for multiplying the tangent of the angle by the distance from the current position to the waypoint.  
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30. The computer program product of claim 23 wherein means, recorded on the recording medium, for piloting in accordance with a navigation algorithm

comprises means, recorded on the recording medium, for identifying a cross track having a cross track direction between the starting point and the  
5        waypoint, and:

means, recorded on the recording medium, for reading from the GPS receiver a current position of the UAV;

10       means, recorded on the recording medium, for calculating an angle between the direction from the current position to the waypoint and a cross track direction; and

15       means, recorded on the recording medium, for piloting the UAV toward the cross track, and

means, recorded on the recording medium, for piloting the UAV in the cross track direction.

31.    The computer program product of claim 30 wherein the threshold angle is a variable whose value varies in dependence upon a distance between the UAV and the waypoint.

32.    The computer program product of claim 23 wherein means, recorded on the recording medium, for piloting in accordance with a navigation algorithm comprises:

5       means, recorded on the recording medium, for reading from the GPS receiver a current position of the UAV;

means, recorded on the recording medium, for calculating a direction to the  
waypoint from the current position;

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means, recorded on the recording medium, for calculating a heading in  
dependence upon wind speed, wind direction, air speed, and the direction to  
the waypoint;

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means, recorded on the recording medium, for turning the UAV to the  
heading; and

means, recorded on the recording medium, for flying the UAV on the heading.

33. The computer program product of claim 23 further comprising means,  
recorded on the recording medium, for identifying a cross track and  
calculating a cross track direction from the starting position to the waypoint,  
and means, recorded on the recording medium, for piloting in accordance with  
a navigation algorithm comprises:

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means, recorded on the recording medium, for reading from the GPS receiver  
a current position of the UAV;

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means, recorded on the recording medium, for calculating a shortest distance  
between the cross track and the current position; and

means, recorded on the recording medium, for piloting the UAV to the cross  
track; and

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means, recorded on the recording medium, for reading from the GPS receiver  
a new current position of the UAV;

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means, recorded on the recording medium, for calculating, in dependence  
upon wind speed, wind direction, air speed, and the cross track direction, a  
new heading;

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means, recorded on the recording medium, for turning the UAV to the new  
heading; and

means, recorded on the recording medium, for flying the UAV on the new  
heading.